The Office of Basic Energy Sciences

The Office of Basic Energy Sciences (BES) is one of the Nation's foremost sponsors of fundamental research in broad areas of materials sciences, chemical sciences, geosciences, biosciences, and engineering sciences. The BES program underpins the Department of Energy's (DOE's) missions in energy and the environment, advances energy-related science on a broad front, and provides unique national user facilities for the scientific community. Encompassing more than 2,400 researchers in 200 institutions and 17 of the Nation's premier user facilities, the program involves extensive interactions at the interagency, national, and international levels.

BES communicates the essence of its mission in three words — excellence, relevance, and stewardship:

- excellence in basic research
- relevance to the Nation's energy future
- stewardship of the Nation's research performers and the institutions that house them to ensure the stability of essential research communities and premier national user facilities.

Combining and sustaining these principles are both the challenge and the vision of the office. Further, taken together, these principles underpin the value to the Nation of basic research.

The Value of Basic Research: An Assessment

Those who conduct, manage, and sustain basic research see its impact and believe in its value. From time to time, however, it is useful to independently assess its value to those outside of the scientific research community. To do so, Dr. Martha A. Krebs, Director of the DOE's Office of Energy Research, asked the Basic Energy Sciences Advisory Committee (BESAC) to assess, without restraint, "how the Nation has received a return on the taxpayer's investment in the Basic Energy Sciences program."

To fulfill this charge, BESAC engaged the help of economist John H. Moore of George Mason University* to head a panel to investigate the question. This panel was unique in that a significant number of its members represented the non-scientific community. It contained influential members from industries, other federal agencies, and Congressional staff, as well as leading scientists from the basic research community. The panel reviewed..

- program information presented by the staff of BES
- testimony presented by technical staff from five other federal agencies (the National Science Foundation, the National Institutes of Health, the National Aeronautics and Space Administration, the U.S. Geological Survey, and the Department of Defense)
- results of other studies including two initiated by the panel
- results of the panel members' site visits to nine national laboratories and two universities that conduct a great deal of BES-funded basic research

The panel's efforts culminated with the BESAC report, *Knowledge for the Nation's Future: The Social Value of Basic Energy Sciences*, which concluded that the research supported by BES provides an excellent return on the investment. The report summarizing the

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panel's work is available from the Office of Basic Energy Sciences.

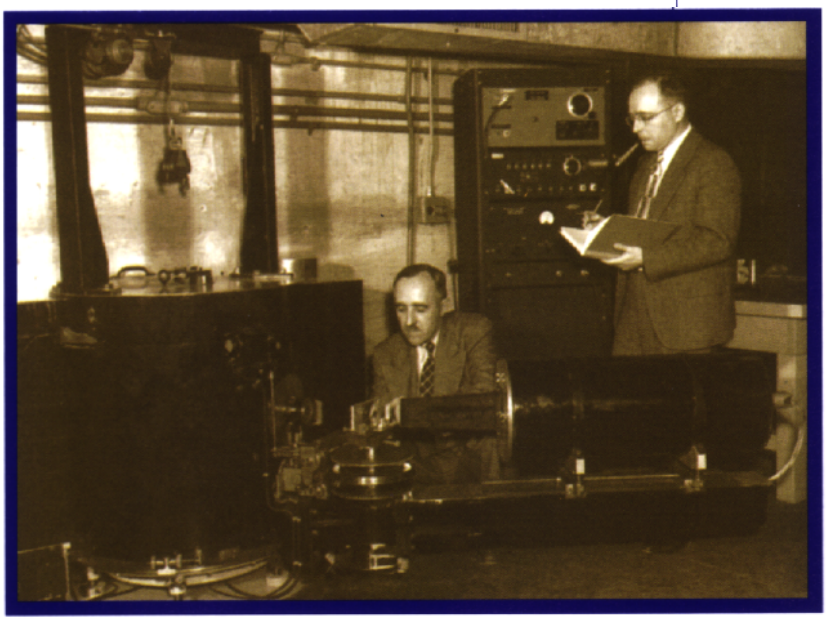
Excellence: Award-Winning Basic Research

Basic research creates the knowledge that underlies and stimulates new technologies. Identifying the best ideas and nurturing the best talent are essential to achieving excellence in a basic research program. To ensure that it funds quality efforts, BES submits each program or project to merit evaluation and peer review. As a result of this constant adherence to the peer review process, BES researchers and their students receive extensive recognition. For example, *within the past decade,* the following BES principal investigators have shared in five Nobel prizes:

- Yuan T. Lee, University of California, Berkeley, for "dynamics of chemical elementary processes" (Nobel Prize in Chemistry, 1986)
- Donald J. Cram, University of California, Los Angeles, for "development of molecules with structurally specific interactions of high specificity" (Nobel Prize in Chemistry, 1987)
- Clifford G. Shull, Massachusetts Institute of Technology, for "pioneering contributions to the development of neutron scattering techniques for studies of condensed matter." (Nobel Prize in Physics, 1994)
- Frank Sherwood Rowland, University of California, Irvine, for "work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone" (Nobel Prize in Chemistry, 1995)
- Richard E. Smalley, Rice University, for "collaborative discovery that carbon could occur in a uniquely beautiful and satisfying structure that engendered an entirely new branch of chemistry" (Nobel Prize in Chemistry, 1996)

One of the hallmarks of the BES program is that its researchers are recognized for their contributions to basic science, applied science, technology development, and R&D integration. BES researchers typically win many of the major prizes and awards in basic science each year, as well as several of the R&D 100 awards.

Over the years, external reviews of BES programs have reached the same conclusions as those of the BESAC panel: the research supported by BES is of high quality, whether it's conducted at the national laboratories, by scientific staff or users at BES user facilities, or by academic researchers.



Neutron scattering was pioneered at Oak Ridge National Laboratory in the 1950s by Nobel Laureate C. G. Shull (standing) and E. O. Wollan.

Relevance: BES and the Nation's Energy Future

BES is uniquely responsible for supporting basic research in the natural sciences that have led to new and improved energy technologies. It supports fundamental research in energy resources, production, conversion, and efficiency, and mitigation of the adverse impacts of energy production and use.

BES also relies heavily on broad input from the scientific community to help define new research directions and to aid the process of integrating basic research with applied research and development activities. For example, BES sponsors or co-sponsors dozens of workshops each year to help define new directions in basic research and to evaluate current technology needs.

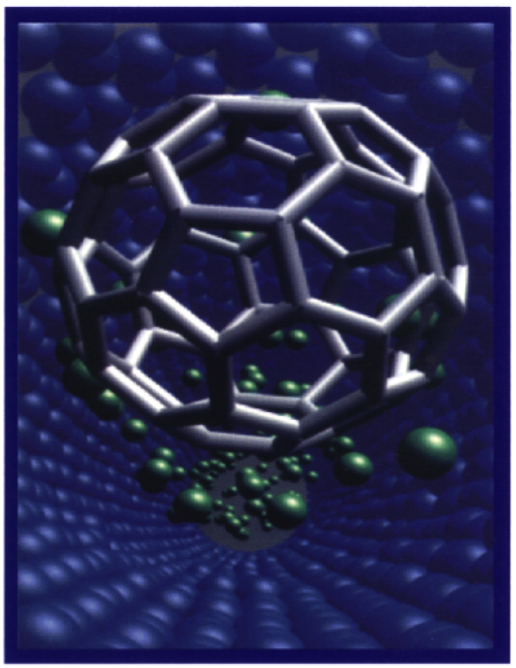
To meet the Nation's future energy needs, the best scientific and technological resources ***must*** be employed together. Through its diversified portfolio of basic research programs and its system of

university and laboratory programs, BES promotes interdisciplinary research such as this and also integrates basic science, applied science, and development activities.

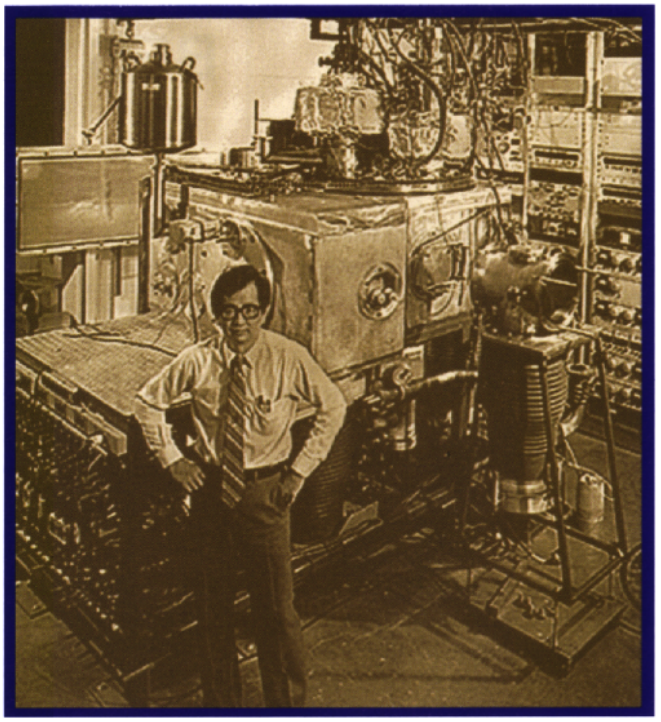
The national laboratory system plays a large part in BES's ability to effectively integrate research and development by providing opportunities to co-locate activities at these sites. Approximately one in every three scientists supported by BES at the national laboratories also receives support from at least one of DOE's technology programs. In this way, BES helps guarantee that energy technology development is conducted with the benefit of state-of-the-art scientific knowledge and that basic research programs are focused in areas directly relevant to energy systems.

More importantly, because revolutionary discoveries often transcend the scope of an original scientific inquiry, BES defines the scope of its programs in broader terms than those defined by DOE technology programs or by industry. In fact, important discoveries can *transform* current technologies. Because of this, BES has linked its funded activities with US. industries so that discoveries such as these can rapidly enter the marketplace.

Basic research also precipitates the invention of new scientific instruments. In a number of key industries, for example, instruments that were first developed as tools for laboratory investigation-as a by-product of the search for new knowledge — have become essential capital goods at the heart of totally new production and technology development.



Buckminsterfullerenes, co-discovered by Nobel Prize winner Richard E. Smalley, are carbon atoms bound in a soccer ball shape.



Nobel Laureate Y. T. Lee's crossed molecular beam experiments revolutionized the fundamental understanding of chemical reactions.

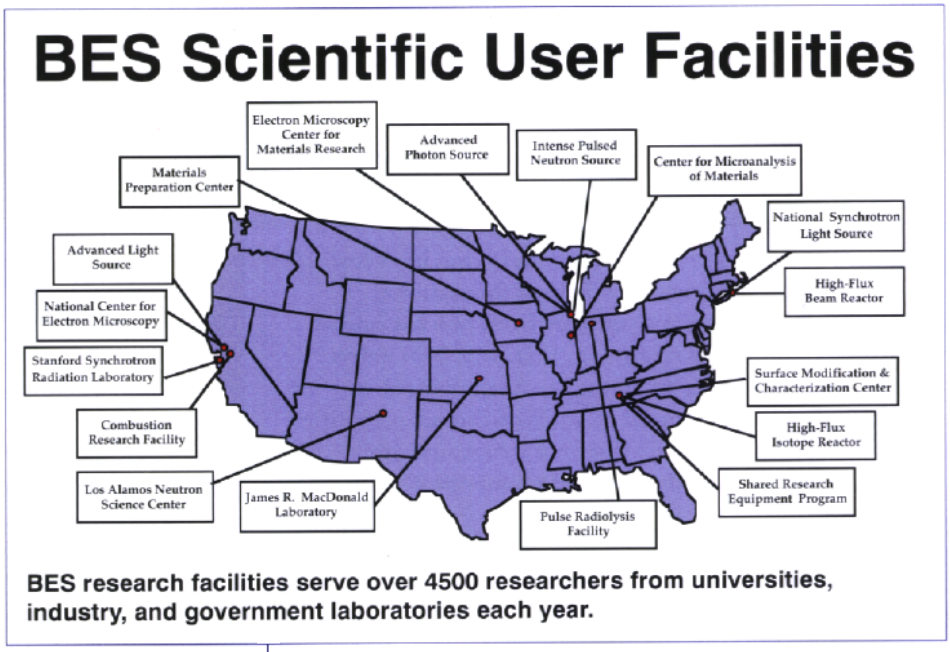
The BESAC report acknowledges the value of BES's strategy for linking basic research with energy technologies and with industry. Given that a deep transformation is happening in the U.S. R&D system, including a shift away from basic research and toward more product-related work, industry is increasingly reliant on fundamental research resources that provide the necessary reservoir of scientific knowledge.

BES's industry R&D strategy is particularly valuable in its heightened focus on research partnerships with outside organizations, especially universities and government laboratories. Industry is relying on R&D at these institutions to maintain the level and diversity of talent and knowledge needed to meet its often unpredictable needs, either in place of, or to supplement, in-house research activities.

To meet these needs, BES designs its programs by means of numerous workshops that involve industry participation and use industrial scientific personnel as

reviewers of university and national laboratory research. The value to industry of these collaborations is evident in industry's use of the results of BES research.

Because BES basic research programs are focused in selected scientific areas important to the mission of DOE, many of these programs have achieved outstanding strength in certain disciplines and subdisciplines. For example, BES is the primary funding entity of basic research in many areas of the natural sciences. One such focus is in organometallic chemistry, which is a fundamental research area in chemical sciences that has great importance to catalysis, Indeed, researchers supported by BES won the first 10 awards in organometallic chemistry following the inception of this award in 1985 by the American Chemical Society.



BES research facilities serve over 4500 researchers from universities, industry, and government laboratories each year.

Stewardship: Supporting the Nation's Basic Researchers and the Institutions that House Them

Many of the hundreds of technological discoveries that transform our lives and improve our standard of living are the result of federally sponsored research, which has long provided a stable environment for scientific discovery. An important function of the BES program, therefore, is its stewardship of the Nation's basic researchers and the universities and national laboratories that house them.

Nationally, BES is one of the major supporters of fundamental research in the physical sciences. In FY 1994, according to an NSF survey, BES programs comprised...

- 24 percent of the total Federal Government funding for research in physics
- 14 percent in chemistry
- 18 percent in metallurgy and materials
- 11 percent in mechanical engineering

BES also funds programs in other fields (the earth and life sciences) that are directly relevant to DOE concerns and complementary to research supported by other Federal agencies. In fact, in some aspects of these programs, BES is the major source of support.

Furthermore, the report noted, BES-funded research also contributes to the Nation's graduate education and knowledge base. BES research provides continuity and support in the university research system and complements the educational role by funding post-doctoral fellows in the laboratories.

BES is also responsible for planning, constructing, and operating many of the Nation's most sophisticated research facilities. These include high-brightness synchrotron light sources, high-flux neutron sources, electron-beam microcharacterization centers, and specified facilities for materials synthesis, combustion research, and ion beam studies.

The 17 facilities operated by BES, which are unmatched in their breadth of capabilities and numbers of scientific users, have an enormous impact on science and technology. Important research in these facilities has ranged from determining the structure of superconductors and biological molecules to developing wear-resistant prostheses, from characterizing environmental samples at the atomic scale to elucidating geological processes, from producing unique isotopes to developing new medical imaging techniques.

The report also recognized the unique role BES has played through its national scientific user facilities, noting that "in its role of a support for the user facilities BES should be viewed as the steward of a critical national resource." The user facilities supported by BES help enable science that would other-

wise be impossible; in fact, the report stated, "an effective national research program could not continue without them. The value of the user facilities flows to the DOE itself, to other Federal agencies, to academia, and to industry..."

Science Serving the Present and Shaping the Future

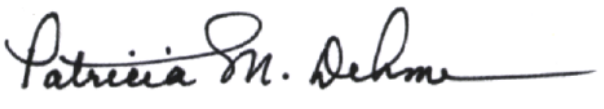
Two earlier publications, *Basic Energy Sciences: Research for the Nation's Energy Future* and *Scientific Research Facilities: A National Resource*, provide an overview of BES and the user facilities supported by BES. These brochures are available from the Office of Basic Energy Sciences.

This brochure focuses on the more than 800 interactions involving BES researchers and industry (BES funds almost no industrial research directly). These collaborations have ranged from informal arrangements among scientists to formal agreements between or among institutions. BES scientists and industrial scientists choose with whom and when to collaborate, each provides their own resources, and each applies the resulting knowledge to their own respective "missions."

In many cases, especially those involving energy industries, the collaborations just naturally grow out of BES-supported research. Other collaborations, however, occur spontaneously, and some have little to do with DOE's energy mission. This is not surprising, since such unexpected applications are the nature of basic research.

The rest of this brochure describes some of the BES-supported research that has made a significant impact on industry. These stories highlight the relevance and truly exemplify the value of basic research. BES could not tell these stories, however, unless the men and women involved strived to achieve the same excellence, relevance, and stewardship. In many ways. these are their stories, too.

November 1, 1996



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The Advanced Photon Source opens new realms of research in the structure of materials.